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ELECTROPLATING ENG *EP -325-798-A
04.04.88-JP-082717 (+JP-004837) *(02.08.89)* B22f-01 B22f-09/08
B23k-35/02

Mfg. device to produce microscopic size powder for solder - uses multiple nozzles under inert atmosphere, producing regular sized powder with non-curved areas suitable to make solder pastes

C89-098494 R(DE FR GB IT)

L(3-H4E4) M(22-G3H, 22-H1, 23-A1)

Molten metal, under an inert gas atmosphere, is extruded under pressure through multiple microscopic sized holes (20 to 90μ in size) in a nozzle, to form a powder of the molten metal.

These powder particles are not perfect spheres but have non-curved parts on their curved surfaces.

These metals such as molten solders of gold alloy, copper alloy or silver alloy form solder powders of these alloys. These solder particles may be kneaded with wax to form solder pastes.

ADVANTAGES

The powders are internally stable because areas of the particles are non current.

Further the outer layers harden on cooling, preventing oxidation of the inside. This makes the paste made from powder very stable over long periods.

By using different size nozzles to size of the powder can be regulated to produce extremely uniform powder size. This gives very good results in painting (printing) on printed circuit boards and is ideal for high density (narrowly spaced) patterns.

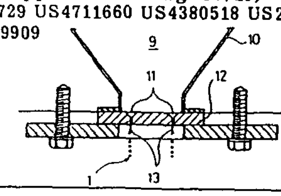
PREFERRED EMBODIMENT

Molten metal (9) in a pressure vessel (18) is passed through an extrusion nozzle (12). This nozzle (12) has microscopic size nozzle holes(11) through which the molten metal (13) continuously falls through the nozzle holes (11).

The droplets (1) fall into an externally water cooler container from where they are extracted.

Both the extrusion and extraction are done under an inert gas atmosphere.(13pp1717RKMHDwgNo7/19)

(E) ISR: WO8401729 US4711660 US4380518 US2811748 WO8603700 DE3109909



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(12) # EUROPEAN PATENT APPLICATION

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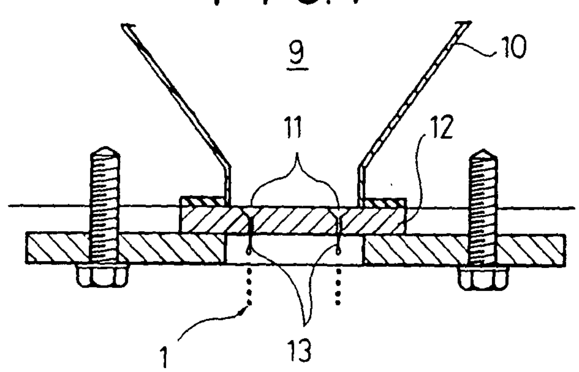
(54) **A metallic powder and a paste made from it, and a metallic powder manufacture device.**

(57) This invention permits the acquisition of a metallic powder (1) microscopic in size (for example between 20 and 90 µm) through a process in which molten metal is extruded from many microscopic nozzle holes (13), the droplets being altered to spherical shapes as they fall while solidifying, such metallic powder having non-curved surfaces in parts of the curved surface of the sphere; this metallic powder being ideal as a metallic powder for solder.

FIG. 7



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solder (powder) in this spherical forms a non-oxidisable sphere, as internal oxidation is avoided through the cooling and solidifying of the outer layer. Examination and enlargement of this sphere (powder) under a microscope indicates that for some reason not entirely clear, part of the curved surface (the surface drawn in a smooth curve) has a non-curved surface part (non-smooth surface with a flat or ridged surface). Through the provision of this non-curved surface on part of the curved surface, the stability of the powder itself is increased, and when a solder paste made by kneading this powder into a flux is printed on. the solder does not "dull". Further a powder of uniform granularity, of a good size distribution and of the microscopic size desired can be obtained efficiently through the said processing i.e. the extrusion of molten metal, without interruption, from a large number of, say 40, nozzles. However, since the solder powder obtained as metallic powder is gained without forcible destruction, in other words without applying a forcible shock, "fine" does not occur and even if the powder is used as paste, solder balls do not occur after solder heating and melting (reflow).

Also, as a device for manufacturing the metallic powder described above, this invention presents a metallic powder manufacture device in which molten metal, under pressure of an inert gas atmosphere, is forced through nozzle holes in an extruding nozzle consisting of multiple nozzle holes, and made to flow, small droplets being made to fall from the tips of continuous vertical hanging parts, the shape of these microscopic droplets being altered from droplet shape to spherical shape as they fall through an atmosphere, and are cooled and solidify.

Further this invention presents as a metallic powder manufacture device, a device in which the arrangement of the nozzle holes has been specially designed. Specifically, in the metallic powder manufacture device described above, the nozzle holes in the nozzle plate are arranged such that when the holes are larger than a constant value determined by the diameter of the nozzle holes, and further are arranged in lines from the circumference of the plate facing a central point, the distance between the holes is larger than the constant value determined by the size of the metallic powder to be manufactured; or the holes may be arranged in one straight line with the interval between the holes being larger than a constant value determined by the diameter of the nozzle holes.

As a result of the arrangement of the nozzle holes as described above, due to a phenomena not entirely understood but difficult to produce with any other arrangement, the random growth of powder by mutual clumping together of droplets as they fall can be prevented, giving a metallic powder which falls within a very narrow range of particle size distribution compared to prior art methods.

Brief Description of the Drawings

Fig. 1 is a partially cut-away side view of the powder,

Fig. 2 is a microscope photograph of the particles at 1000 times magnification showing that the powder has no fine, and part of the curved surface has a non-curved part,

Fig. 3 is a side view showing a chip mounted on the printing circuit board, using solder paste,

Fig. 4 is a microscope photograph of the particles at 150 times magnification showing powder of a uniform size, around 37-90 µm in diameter,

Fig. 5 is a microscope photograph at 200 times magnification showing that there is no conspicuous occurrence of solder balls after heating and melting (reflow) of the solder,

Fig. 6 is an overall side view of the device, partially cut-away to indicate the metallic powder manufacture device,

Fig. 7 is an enlarged side section view of the extruded nozzle area,

Fig. 8 is a partially cut-away outline side view of another embodiment of the "solder" powder manufacture device,

Fig. 9 shows a partial side sectional view of the bottom of the pressure vessel,

Fig. 10 is an overall perspective view of the nozzle plate,

Fig. 11 is an expanded sectional view of the nozzle holes,

Figs. 12 to 14 are outline plan views showing different arrangements of nozzle holes,

Fig. 15 is a microscope photograph of the particles at 100 times magnification,

Fig. 16 is a microscope photograph of the particles at 500 times magnification,

Fig. 17 is a partially cut-away outline side view showing another embodiment of the "solder" powder manufacture device,

Fig. 18 is a microscope photograph of the particles obtained using the previous atomization method, magnified 500 times, and

Fig. 19 is a microscope photograph of solder balls.

Description of the Preferred Embodiments

The embodiments of this invention will be described with reference to the drawings. In this description, "metallic powder" and "paste" have many of the same features so where necessary for

e. Where nozzle holes of around 18μm in size are used, the average size of the powder is 55-60μm, providing a very uniform powder without any fine.

f. Since an extremely evenly sized powder is obtained, solder paste made using this powder performs well in painting (printing) on printed circuit boards and is ideal for high-density (narrowly spaced) patterns.

Next, a second embodiment of this invention will be described with reference to Figs. 8 to 16.

In the above and following description the terms "metallic particle" and "particle" are used in the broad sense of the words, meaning both one particle and a collection of multiple particles.

Further in the description of this embodiment, the words "metallic powder" and "powder" are used interchangeably.

This embodiment involves a "solder" particle manufacture device 101 which is used to manufacture "solder" particles.

This "solder" particle manufacture device 101, as shown in Fig. 8, is constructed of a pressure vessel 102, a case 103 and a powder extractor 104, connected serially from top to bottom, with a nozzle plate 105 mounted at the bottom of the pressure vessel 102.

The nozzle plate 105 consists of a plate 110 pierced with multiple microscopic nozzle holes 111. The arrangement of these nozzle holes 111 is such that if the interval W between the nozzle holes 111 is larger than the constant value assigned in accordance with the diameter R of the nozzle holes 111, or more specifically is greater than R x 100, and the nozzle holes 111 are arranged in lines L facing a central point from the circumference of the plate 105, that interval is larger than the constant value determined by the correlation with the particle size of the metallic particles to be manufactured. In other words, in general, the sole condition for the arrangement of holes is that the distance between the holes is must be greater than the constant value determined by the diameter R of the nozzle hole 111. Where the holes are aligned along the lines L, the arrangement must be such that the holes are not positioned at intervals smaller than the fixed value determined by the correlation with the size of the metallic particles. Two specific examples of arrangements are the circular arrangement shown in Fig. 10 and the double circular arrangement shown in Fig. 12. These are the most advantageous arrangements both in order to prevent the random growth of the droplets C during their descent, as a result of mutual cohesion, but also from the point of view of maintaining at a uniform temperature, the respective molten solder A and molten solder B extruded from the nozzle holes 111. However, the square arrangement shown in Fig. 13 and a linear arrangement with the opposing two sides of the square removed, may also be used. The linear arrangement shown in Fig. 14 can also be employed since if only the condition determined by the diameter R of the said nozzle hole 111 is satisfied, the said condition determined by the correlation of the size of the metallic particles no longer applies. Further, each of the nozzle holes 111, as indicated in Fig. 11, is shaped with an upper tapered guide part 112. This tapered guide part 112 has the advantage of facilitating a smooth flow of solder A (described later). Experiments proved that the diameter R of the nozzle hole 111 is ideally approximately one-third of the size of the "solder" particle Pa. In this embodiment, the size of the nozzle hole was 18 μm, giving a solder particle Pa with an average diameter of approximately 55-65 μm.

The pressure vessel 102 contains molten solder A, and is used to heat it and maintain its temperature at approximately 250 degrees C. In the middle it has a thermo-couple 113 and on the periphery a band heater 114, with a nozzle plate 105 mounted at the bottom as described above. This pressure vessel 102 is sealed tightly, and connected to it there is an inert gas introduction means 115, such that an inert gas atmosphere is maintained inside the pressure vessel 102 and a certain pressure P can be applied to the molten solder A. 116 is a filter, which is mounted on the nozzle plate 105 in order to filter out oxidized particles of solids which are mixed in the molten solder A. The ideal materials for this filter 116 are glass fiber filter paper, silica fiber filter paper, or quartz fiber filter paper, which should be fire-resistant to more than 500 degrees C.

The case 103 is constructed of a processing space 117, divided into sections, and overall having a tubular shape. The case 103 is external to the nozzle plate 5, and is designed for the purpose of creating particles Pa from the molten solder A forcibly extruded in threads from the nozzle holes 111 on the nozzle plate 105 as a result of the pressure P; specifically by altering the overall shape of the droplets C which are dropped from the tip of the thread-shaped part B, from a droplet shape to a spherical shape as they cool while falling through the inert gas atmosphere and solidify into particles. The molten solder A falling continuously in threads from each of the nozzle holes 111 creates an effect like that of a shower. In the middle of case 103 a cooling jacket 120 connected to a cooling water inlet 118 and an outlet 119, constructed as a double wall, is provided. The height of case 103 influences the size of the processing space 117; an ideal height is such that the droplet C which falls from the tip of the thread-

the tips of these threads, these small droplets changing their whole shape from droplet shape to spherical shape as they cool and solidify while falling; with regard to the size of the metallic particles thus formed, the occurrence of particles below a certain size, particularly "fine", is avoided, and further because the arrangement of nozzle holes is also fixed, the random growth of particles by clumping together while falling is prevented, due to a phenomena not entirely understood but extremely difficult to produce with any other arrangement; through these means it is possible to obtain a powder made of metallic particles within a narrow particle size distribution range compared with prior art methods.

This invention permits the acquisition of a metallic powder microscopic in size (for example between 20 and 90 µm) through a process in which molten metal is extruded from many microscopic nozzle holes, the droplets being altered to spherical shapes as they fall while solidifying, such metallic powder having non-curved surfaces in parts of the curved surface of the sphere; thus metallic powder being ideal as a metallic powder for solder.

Claims

1. A metallic powder made by extrusion of molten metal from multiple microscopic nozzle holes in an inert gas atmosphere, cooled while falling, and during that cooling changing its overall shape from droplet shape to spherical shape and hardening, said metallic powder characterized by having non-curved parts on parts of the curved surfaces forming the sphere.

2. The metallic powder of Claim 1 in which the molten metal is molten solder and the metallic powder is solder powder.

3. A solder paste made by kneading the solder powder of Claim 2 into flux.

4. The metallic powder of Claim 1 in which the molten metal is either molten copper alloy, molten gold alloy or molten silver alloy, and the metallic powder is copper alloy powder, gold alloy powder or silver alloy powder.

5. Copper paste, gold wax, or silver wax made by kneading the powders of Claim 4.

6. A metallic powder manufacture device in which molten metal, under continuous pressure of an inert gas atmosphere, is forced through nozzle holes in an extrusion nozzle provided with multiple nozzle holes, small droplets being made to fall from the tips of these continuous hanging shapes, the shape of these microscopic droplets being altered from droplet shape to spherical shape as they cool and solidify while falling continuously at the atmospheric pressure created by the inert gas.

7. A metallic particle manufacture device in which molten metal, under continuous pressure of an inert gas atmosphere, is forced through nozzle holes in a nozzle plate provided with multiple nozzle holes in the plate, making it flow in thread-like shapes, small droplets being made to fall from the tips of these thread-like shapes, the shape of these microscopic droplets being altered from droplet shape to spherical shape as they cool and solidify while falling continuously at the atmospheric pressure created by the inert gas; the metallic particle manufacture device being characterized, where the nozzle holes in the nozzle plate are arrayed in lines extending from the circumference of the plate and facing towards the center, and the distance between the nozzle holes of the nozzle plate being a greater distance apart than a fixed value determined in accordance with the size of the nozzle holes, by an arrangement of the holes so that the distance between the holes is larger than a constant value determined in accordance with the size of the metallic particles to be manufactured.

8. The metallic particle manufacture device of Claim 6 or Claim 7 further
characterized by the nozzle holes on the nozzle plate being arranged in straight lines, with the distance between the nozzle holes being greater than a fixed value determined in accordance with the size of the nozzle holes.

9. The metallic particle manufacture device of Claim 6 or Claim 7 characterized by
the fact that the size of the metallic particles being manufactured is less than 100 µm, and the size of the nozzle holes being approximately one-third of the size of the metallic particles.

10. The metallic particle manufacture device of Claim 7 or Claim 8 characterized
by the nozzle holes of the nozzle plate being arranged in one circle.

11. The metallic particle manufacture device of Claim 7 or Claim 8 characterized
by the nozzle holes of the nozzle plate being arranged in two circles, and not so that the nozzle holes in these circles are arranged in lines extending from the circumference towards a central point.

12. A metallic particle manufacture device constructed serially from top to bottom of : a pressure vessel provided at least with a furnace containing molten metal, with a nozzle plate furnished with nozzle holes and formed at the bottom of the furnace, and a means of introducing inert gas into the furnace; a case provided with at least an introduction means and a discharge regulation means for introducing inert gas to the internal processing space and discharging it, the lower part of the case body shaped in an inverse conical shape; and a cooling means covering the exterior surface;

FIG. 1

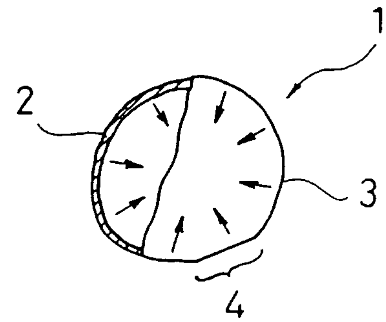


FIG. 2

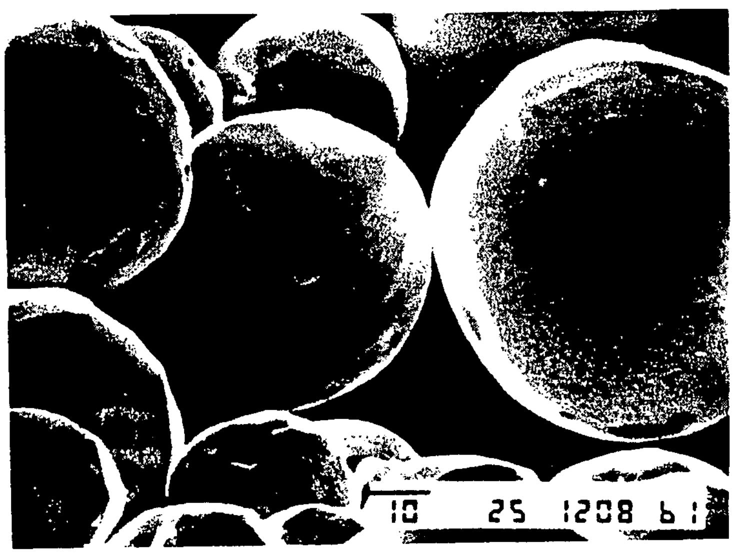


FIG. 3

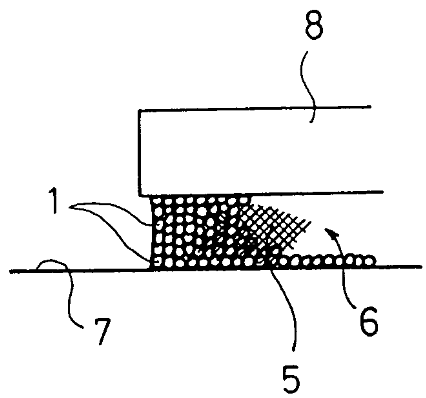


FIG.4

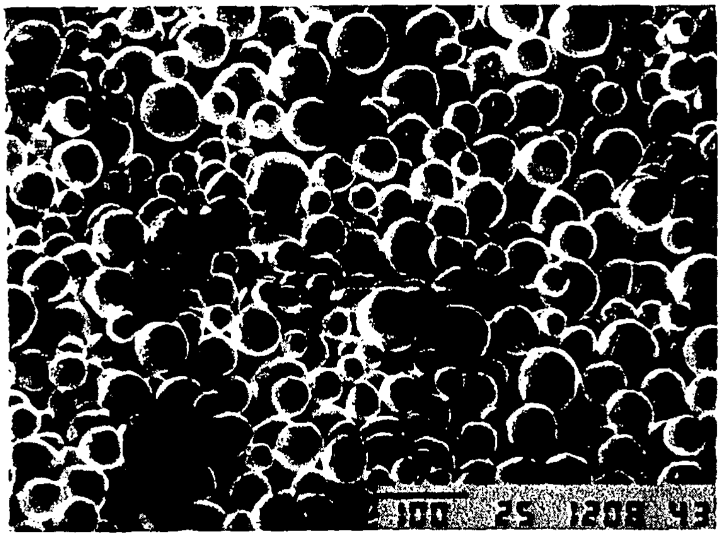


FIG.5

F I G. 6

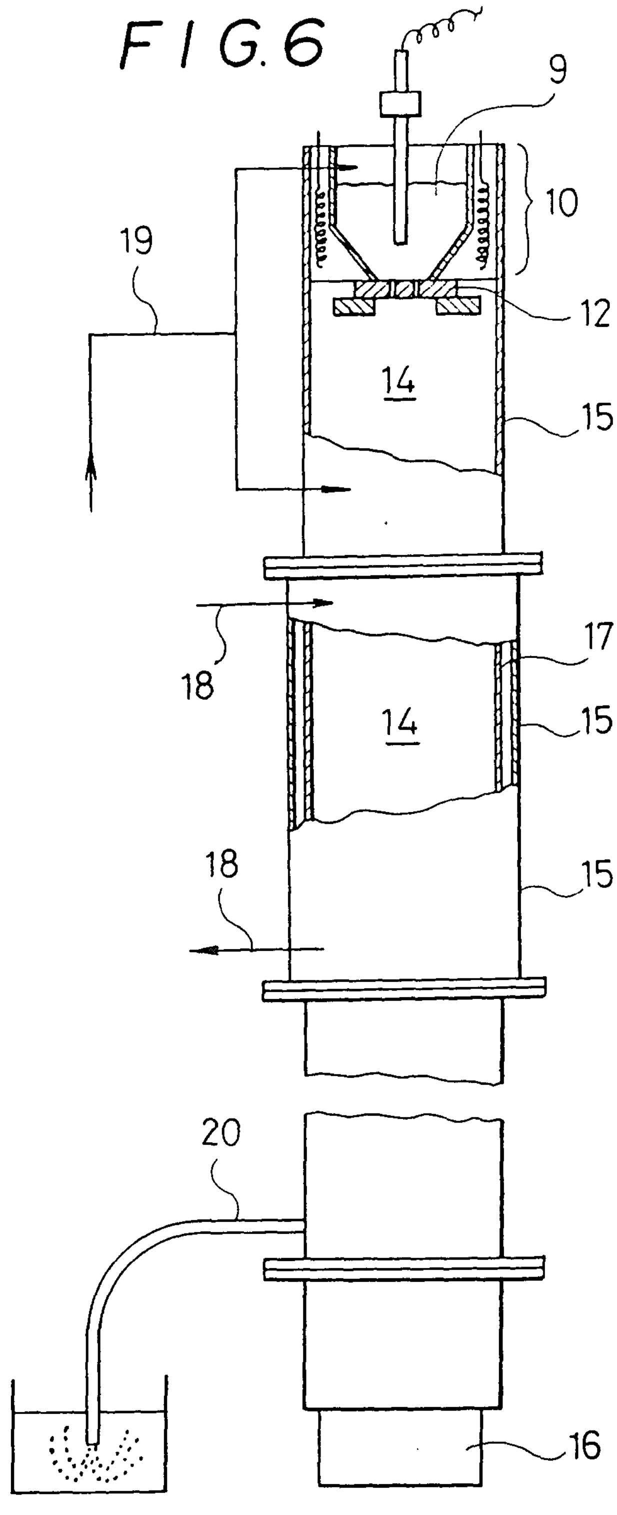
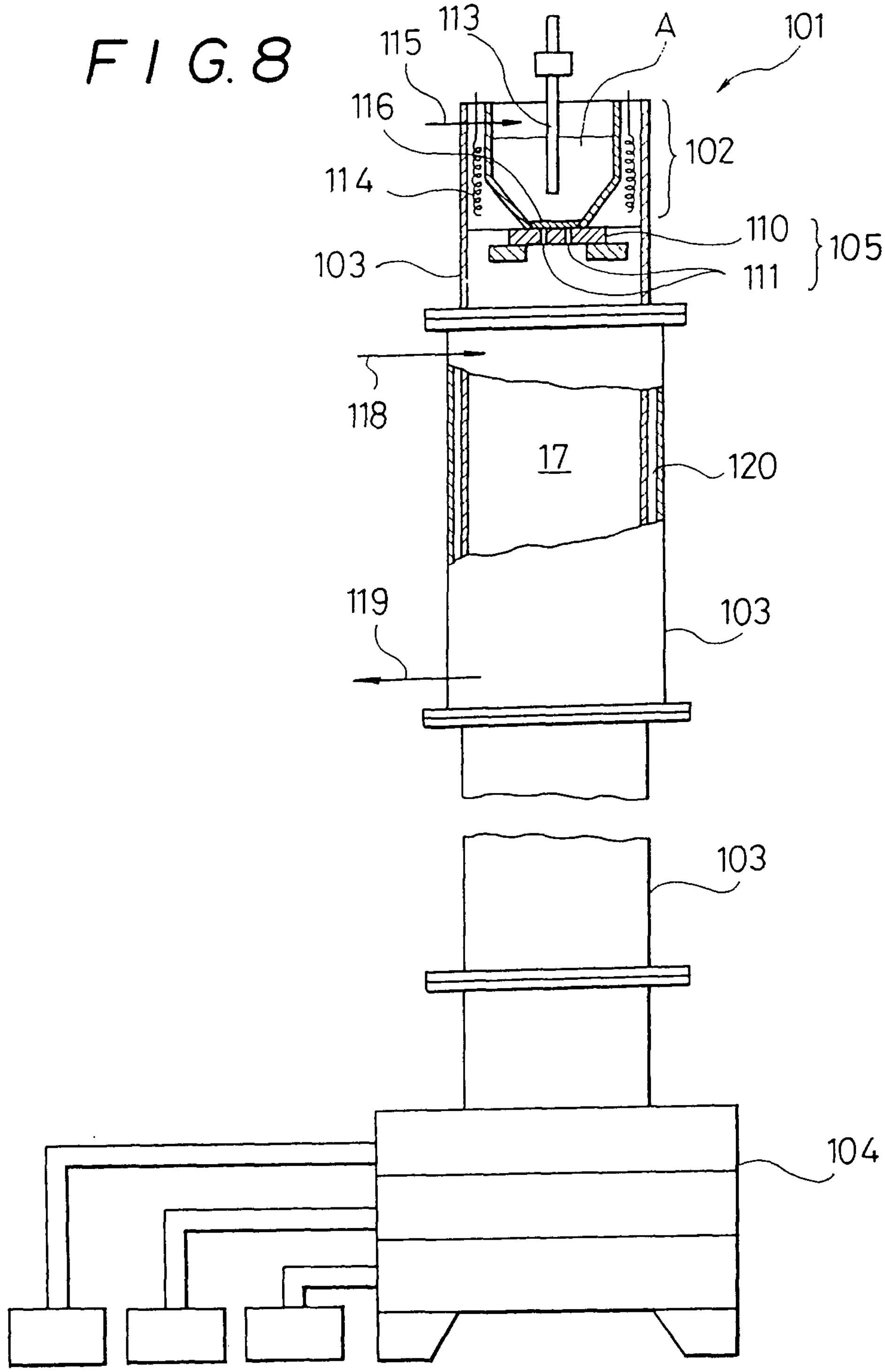


FIG. 8



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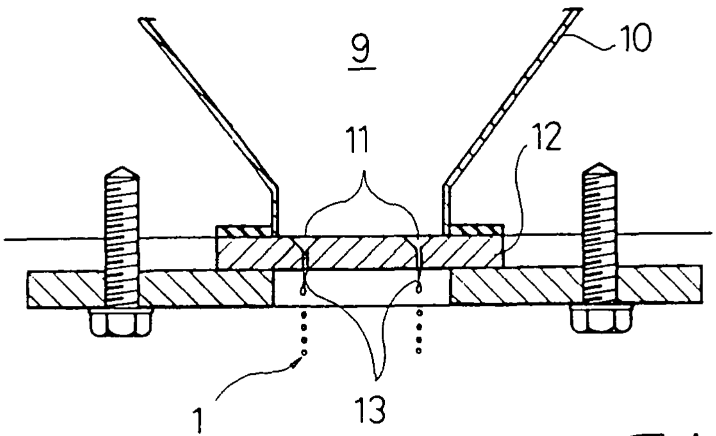
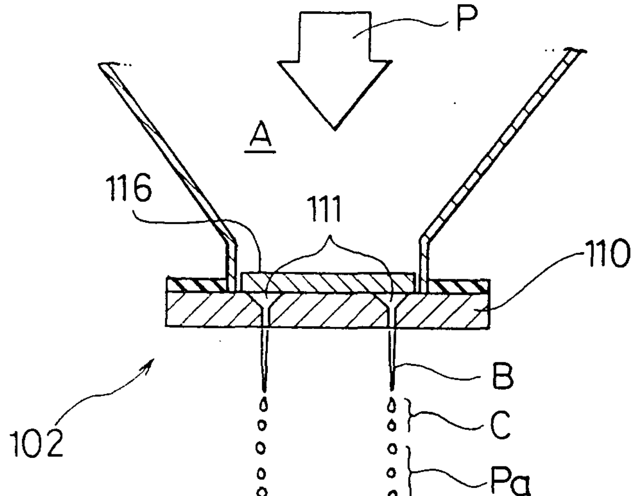
F I G. 7



F I G. 9



F I G. 10

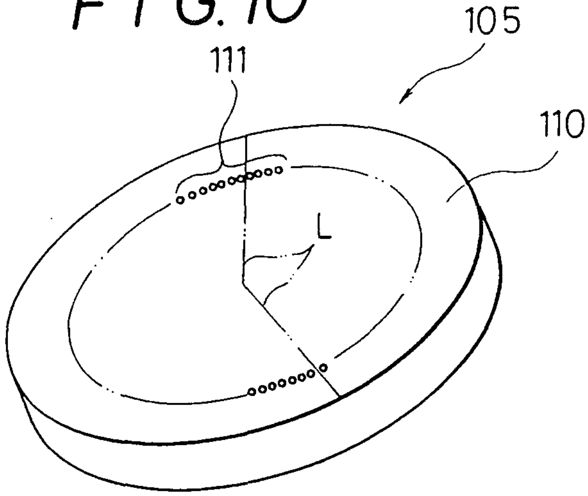


FIG.11

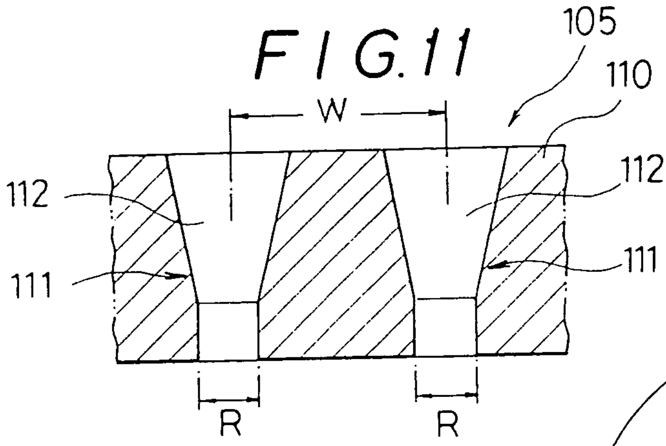


FIG.12

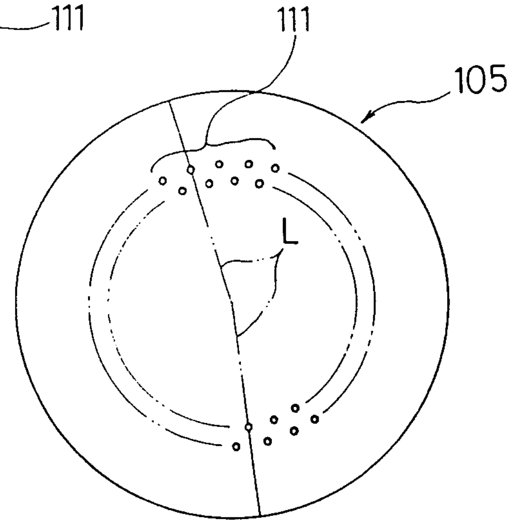


FIG.13

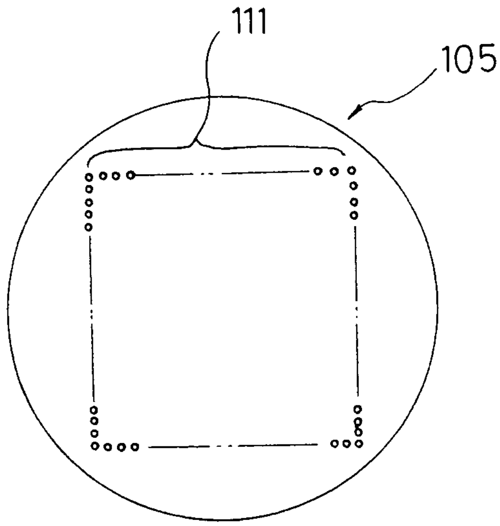


FIG.14

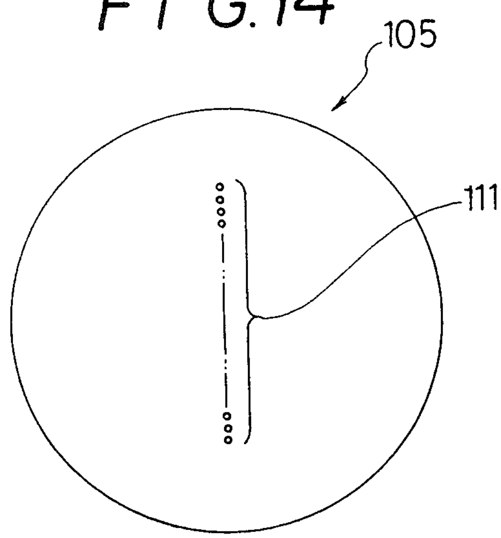


FIG. 15

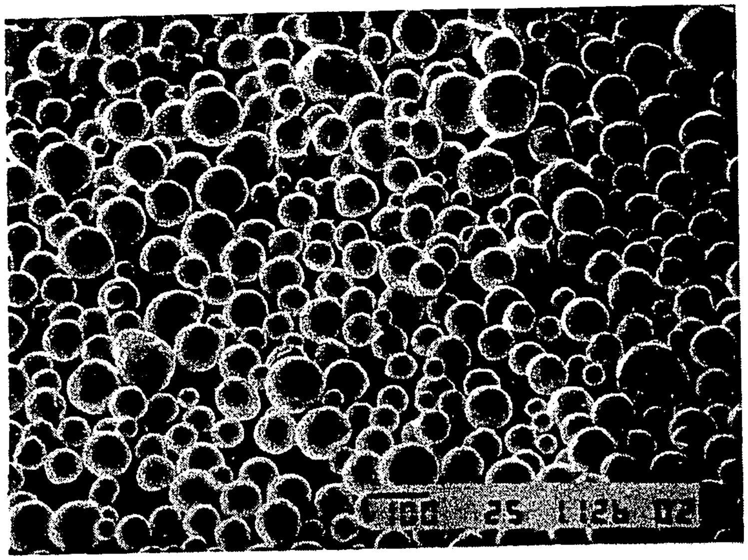


FIG. 16

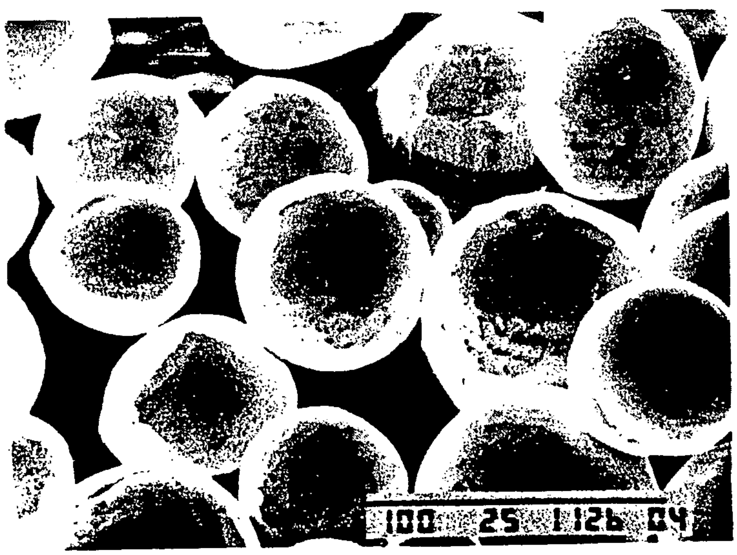


FIG. 17

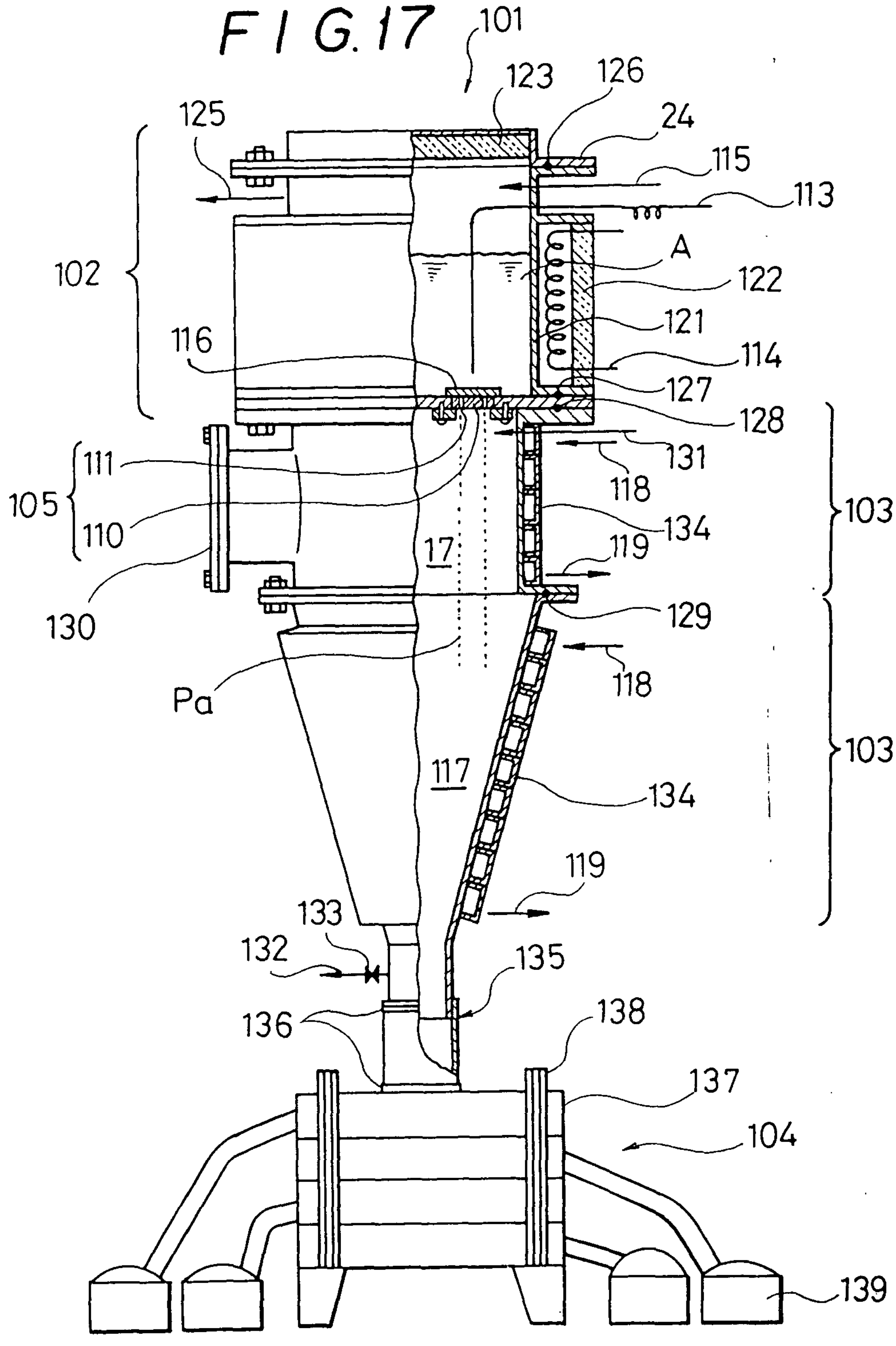


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FIG. 18

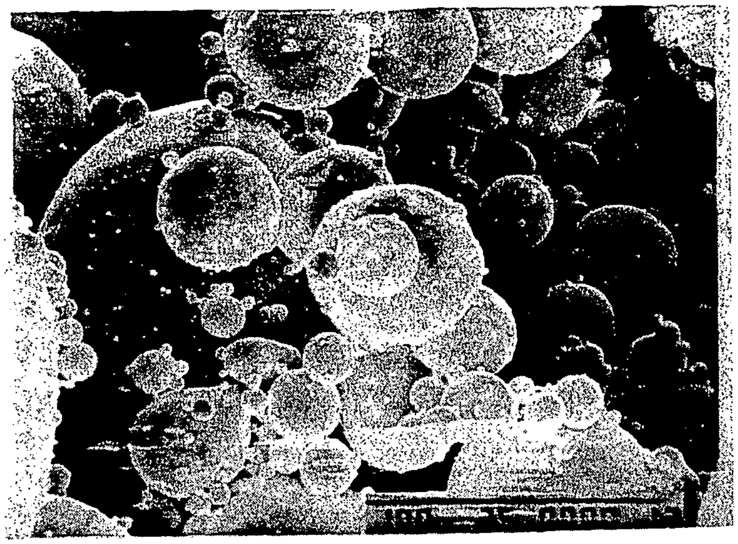
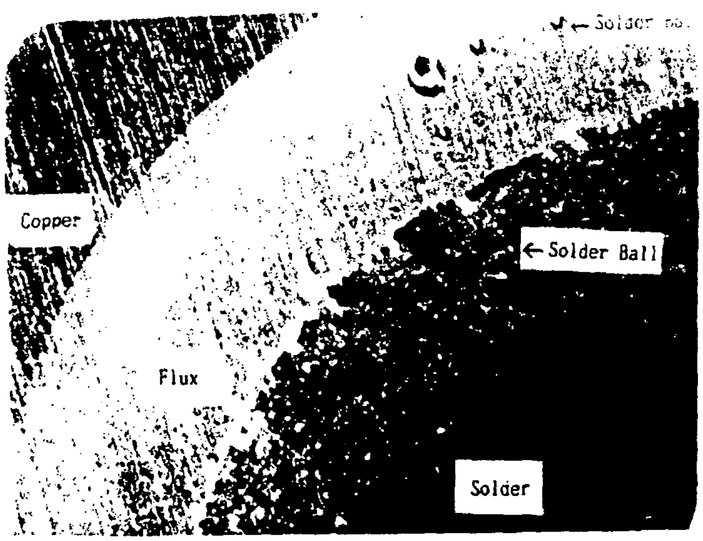


FIG. 19



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EUROPEAN SEARCH REPORT

Application Number

EP 88 12 1809

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X Y A	WO-A-8 401 729 (BALASSA) * Page 3, line 32 - page 4, line 38 *	1,6,8 2-5 7,12,13	B 22 F 9/08 B 22 F 1/00 B 23 K 35/02
Y	US-A-4 711 660 (KEMP, Jr. et al.) * Abstract; column 4, lines 26-40 *	2-5	
A	US-A-4 380 518 (WYDRO, Sr.) * Column 1; figures 1,4 *	1-5	
A	US-A-2 811 748 (SMITH) * Column 1, lines 23-28 *	9	
A	WO-A-8 603 700 (MITSUBISHI KINZOKU K.K.)		
A	DE-A-3 109 909 (KOPPATZ)		

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

B 22 F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	25-04-1989	ASHLEY G.W.

CATEGORY OF CITED DOCUMENTS

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